JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

PROJECT DOCUMENT 32-S/MA

SURVEYOR MISSION A

FLIGHT TEST OBJECTIVES

PD 32-S/MA June 11, 1965

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Prepared Under Contract No. NAS 7-100
National Aeronautics & Space Administration

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FOREWORD

This document, PD 32-S/MA, is in effect an extension of the Surveyor Project Mission and Flight Objectives document (PD-31) since it expands upon the obligation imposed by the flight objectives. Because the flight objectives stated in PD-31 are of necessity given in broad terms, it is the intent to delineate them in PD 32-S/MA in terms of flight test objectives--detailed mission obligations which if met individually will bring about the accomplishment of the flight objectives.

The series of Surveyor Project Mission and Flight Objectives documents will be issued under the PD-32 basic number. Each issue will be identified with a postscript, e. g., PD 32-S/MA indicates the issue for Mission A, PD 32-S/MB for Mission B, etc.

This document supersedes PD-32, Surveyor Mission A, Flight Test Objectives, January 6, 1965.

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I. SCOPE

The scope of this document is limited to the NASA Surveyor Project, Mission A.

A. PURPOSE

This document defines, in detail, the significant performance requirements which must be properly demonstrated during flight test operations to prove the adequacy of the Surveyor A mission design. Further, it shall serve as a guide in the design of all elements of the Surveyor Project and in the conduct of all operations through mission completion.

This document shall serve as the controlling document in determining mission success and evaluating Project accomplishment at any point in the Mission A flight program.

B. DOCUMENT MAINTENANCE

This document will be maintained by JPL, and revisions will be published as needed to ensure that its content remains current. Suggested changes, additions, or deletions should be directed to the Manager, Mission Analysis and Engineering, Surveyor Project. After necessary coordination and approval, changes will be incorporated into the document.

C. SURVEYOR MISSION A FLIGHT OBJECTIVES

The Surveyor Mission A. Flight Objectives* are as follows:

1. Primary. Demonstrate successful operation of the launch vehicle, spacecraft, spaceflight operations, and DSIF, and the ground communications from launch through completion of the midcourse maneuver.
2. Secondary. Demonstrate successful spacecraft operation from the the completion of the midcourse maneuver through landing.
3. Tertiary. Perform post-landing functions.

*The Flight Objectives are quoted verbatim from the Surveyor Project Objectives and Flight Objectives for Missions A through D, PD-31, March 15, 1965.

Implicit in the philosophy of flight testing is the requirement of obtaining design information for the correction of design difficiencies disclosed by the flight and for use in designing future projects. Although not stated explicitly in the flight objectives, they do include the obtaining and evaluation of design information data. The individual activities and events which must occur during the mission to accomplish the three (primary, secondary, and tertiary) flight objectives are defined as flight test objectives.

II. FLIGHT TEST OBJECTIVES ESTABLISHMENT AND CONTROL

A. GENERAL

The philosophy of the flight test objective concept has been established in the development of large aerospace systems such as aircraft, ballistic missile, and military space systems. Once the flight test objectives have been established, they may be assigned to each mission in a logical manner to ensure reasonable, progressive achievement of the flight objectives. The disadvantage in not establishing such a program is that optimism in such areas as mission planning and control may preclude, not only the recovery of essential failure-mode data, but also the establishment of sufficient confidence in system design.

Many functions which must be accomplished successfully on Mission A are not delineated as specific flight test objectives in this document. These are functions which have been validated on previous launches. For example, many functions of the launch vehicle system fall into this category. It is implicit that these functions are required on Mission A.

B. DEVELOPMENT

Prior to the initiation of flight operations, the Spacecraft System will undergo comprehensive, ground environmental testing to quality the design. Extensive ground testing will be accomplished to establish the functional compatability of the spacecraft with the interfacing ground complex and launch vehicle, and to verify operational readiness of the complete system complex including personnel and software. The objectives of the flight are therefore concerned with the accomplishment of those functions which can be fully tested only during the actual flight or after the lunar landing.

The goal of the developmental missions is the verification of the spacecraft's capability to reliably land and satisfactorily operate on the lunar surface. The flight test objectives of Mission A are contained in Section III. These are a compilation of all test requirements whose successful accomplishment will demonstrate spacecraft performance in all aspects which lead to achievement of this goal. The objectives and their priorities require detailed, continuing review by each subsystem design area, system engineering, and project management.

C. APPLICATION

The flight test objectives delineated herein are to be used for mission planning and during mission operations in several ways.

This document shall be used as a guide in the allocation of manpower, resources, funds and effort throughout the mission. In no case, however, shall action be taken which will preclude the ability to achieve any flight test objectives unless such action is approved by the Project Manager or Mission Director.

This document will be used in scheduling launches and evaluating launch readiness. This use is particularly important due to the existence of critical launch periods and launch windows. The establishment of launch-hold criteria will be influenced by the priority allocation of each flight test objective.

The flight test objectives will also be used to determine the proper course of action for both standard and non-standard situations during the flight. The success of the flight will be measured in terms of achievement of the flight test objectives.

The successful utilization of the flight test objective concept requires the feedback of test data to the design areas for evaluation, analysis, and design review. It is probable that design deficiencies will be discovered during flight testing which could delay future flights until appropriate corrections are made, or would indicate the desirability of significantly increasing performance prior to further flights. Unless project control procedures are established to accommodate these design changes in flight hardware on an expedient basis, unnecessary launch delays may result.

Finally it is re-emphasized that it is imperative to attempt accomplishment of as many flight test objectives as is feasible in order to secure as much performance data as possible. Adequate flight data are essential in order to reach a valid judgement of spacecraft performance at the completion of Mission A.

D. PRIORITY DEFINITIONS AND LAUNCH-HOLD CRITERIA

Each flight test objective is assigned an accomplishment priority number which is based on a gross estimate of the effect of each flight test objective on the successful accomplishment of its related flight objective. The three classes of priority are listed below.

1. Priority 1 Flight Test Objectives

These flight test objectives are essential requisites for attaining the Mission A primary flight objective. Items relative to these flight test objectives will receive first priority in resource allocations. If any of these flight test objectives are jeopardized, the launch will be held unless the Mission Director specifically waives the requirement for these flight test objectives at the time of launch.

2. Priority 2 Flight Test Objectives

These flight test objectives are essential requisites for attaining the Mission A secondary flight objective or highly desirable requisites for attaining Mission A primary flight objective. Items relative to these flight test objectives will receive second priority in resource allocations. If any of these flight test objectives are jeopardized, the launch may be held for one or two months if such a period would be sufficient to correct the problem and the problem was discovered early enough so that the delay could be implemented without other serious adverse effects. Again, the Mission Director has the authority to specifically waive the requirement for any flight test objective at the time of launch.

3. Priority 3 Flight Test Objectives

These flight test objectives are essential requisites for attaining the Mission A tertiary flight objective, highly desirable requisites for attaining the Mission A secondary flight objective, or desirable requisites for attaining the Mission A primary flight objective. Items relative to these flight test objectives will receive third priority in resource allocations. If any of these flight test objectives are jeopardized the launch will not be held.

E. TERMINOLOGY

Each definition of a flight test objective commences with one of the four terms listed below. These terms have been defined to provide a consistent interpretive meaning of what must be achieved in a technical and operational sense to satisfy each flight test objective.

Each flight test objective will fit within one of the four categories as defined by these terms. In some instances, a similarity will be evident between different flight test objectives. In such instances, the key difference will be the distinction among these four categories, demonstrate, validate, determine and evaluate.

1. Demonstrate

This denotes a qualitative assessment of whether a flight or lunar operating event or activity has been satisfactorily accomplished. The appraisal will be made with a minimum of flight instrumentation, and/or the information will be obtained externally to the spacecraft or launch vehicle. The activities required to achieve this category of flight test objectives will occur almost entirely during the mission with some effort required for postflight analysis.

2. Validate

This denotes the appraisal of the operational procedures, computational techniques, command and control methodology, etc., used for achieving flight or lunar functions or activities. The emphasis is to be on the efficiency and effectivity of the operational support processes. The activities required to achieve this category of flight test objectives will occur almost entirely during the mission with some effort required for postflight analysis.

3. Determine

This denotes the measurement of the system, subsystem, or equipment performance which affects the satisfactory accomplishment of a flight or lunar operational event or activity. This category implies the provision of an instrumentation capability. This data gathering capability should be adequate for investigating to what extent an activity or event was achieved within operating and/or design limits, and to allow performance deficiencies to be isolated to the subsystem level. The activities required to achieve this category of flight test objectives will occur, for the most part, during the mission. However, substantial effort will be required for postflight analysis.

4. Evaluate

This denotes the measurement of the performance of a subsystem and its components (and/or its functional interaction with other subsystems) which affects the satisfactory accomplishment of a flight or lunar operational event or activity. The performance of subsystem components will be analyzed for their contribution toward satisfactory accomplishment of the objective. Evaluation will require the gathering of engineering data for use in augmenting supplemental, analytical investigations such as environmental studies, component performance studies, time-history plots, etc. This category will require the most detailed use of flight and ground information sources. The activities required to achieve this category of flight test objectives will occur, for the most part, during the post-flight period. However, substantial effort will be required during the flight.

III. SURVEYOR MISSION A FLIGHT TEST OBJECTIVES

The mission sequence is divided into nine phases, as illustrated in Fig. 1. Where necessary, priority ratings of the flight test objectives are divided into two intervals, pre-midcourse and post-midcourse. As a result, Phases 3, 4, and 5 are comprised of the two intervals, "a" (pre-midcourse) and "b" (post-midcourse). The Transit phase (Phase 3) lists those objectives which are to be accomplished from DSIF acquisition to lunar touchdown. During Phase 3, the following phases also occur: Phase 4, Attitude Reference Acquisition; Phase 5, Coast; Phase 6, Midcourse; and Phase 7, Terminal Maneuver, Retro, and Vernier Descent. These four phases are listed separately from the transit phase in order to specify those additional flight test objectives applicable only during these portions of the mission sequence. Thus, to achieve all of the flight test objectives applicable to Phases 4, 5, 6, or 7, the flight test objectives listed in Phase 3 must be achieved in addition to those flight test objectives listed separately within Phases 4, 5, 6 or 7.

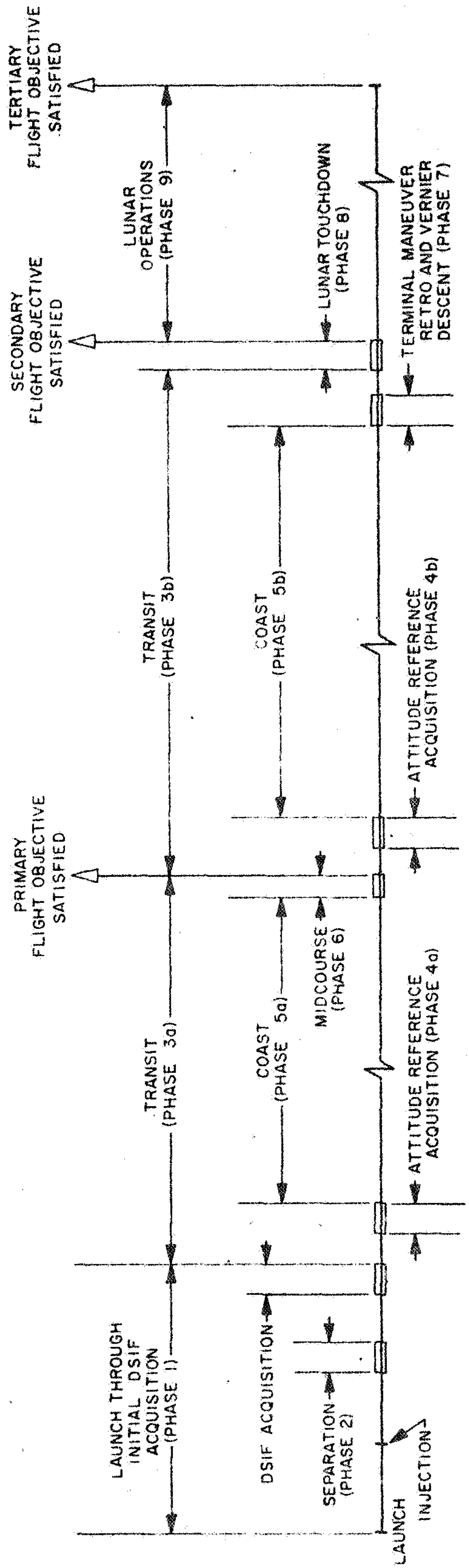

Fig. 1. Phase definitions, Surveyor Mission A

Phase 1. Launch Through Initial DSIF Acquisition*		Priority
1.1	Demonstrate the capability of the composite space vehicle and supporting systems to launch within any established launch window in a launch period.	2
1.2	Demonstrate the capability of the spacecraft to maintain functional operational and structural integrity during launch and Atlas/Centaur powered flight.	1
1.3	Demonstrate proper operation of the spacecraft/launch vehicle mechanical, electrical, and RF interfaces throughout the launch to separation interval of flight.	1
1.4	Demonstrate the occurrence of Centaur spacecraft nose fairing jettison as programmed.	1
1.5	Validate the capability of the AFETR to receive and record spacecraft telemetry via the Centaur or spacecraft links during the intervals specified in PRD 3400.	1
1.6	Validate the capability of the AFETR down-range stations to retransmit spacecraft telemetry data in real time.	2
1.7	Validate the capability of the AFETR to obtain and process tracking data for flight path determination during Atlas/Centaur powered flight for range safety purposes and post-flight launch vehicle evaluation.	1
1.8	Validate the capability of the AFETR to obtain and process tracking data, as specified in PRD 3400, for flight path determination in order to obtain orbital elements, injection conditions, and DSIF look angles, and to transmit these calculated data and raw tracking data to the SFOF in Pasadena in near-real time.	1
1.9	Evaluate spacecraft response to the launch-to-injection environment imposed on the spacecraft.	1

*DSIF acquisition is defined in detail for Missions A and B in EPD-238, "DSN Commitment Document for the Surveyor Project," Dec. 18, 1964

		Priority
Phase 1.	(Cont'd)	
1.10	Demonstrate the capability of the launch vehicle to perform as programmed while carrying a total Surveyor spacecraft.	1
1.11	Evaluate Centaur guidance system telemetry data to establish inertial position and velocity of the Centaur during the interval between injection and completion of the Centaur retro.	2
1.12	Demonstrate spacecraft injection within the mid-course correction capability.	1

		Priority
Phase 2.	Separation	
2.1	Demonstrate proper response of the spacecraft to pre-separation commands.	1
2.2	Demonstrate the capability of the Centaur separation system to separate the spacecraft within the required velocity and rotation rate intervals.	1
2.3	Evaluate the spacecraft velocity increment and angular rates imparted at Centaur spacecraft separation.	2
2.4	Demonstrate the capability of the spacecraft flight control system to null rotation rates imparted at separation and to maintain a stabilized attitude.	1
2.5	Demonstrate achievement of the required separation distance between the spacecraft and Centaur within the specified time.	2
2.6	Demonstrate spacecraft capability to execute the automatic Sun-acquisition sequence including solar panel capability to position and lock in transit position, and spacecraft lock-on, and precision tracking of the Sun.	

Phase 3. Transit

The following objectives are to be accomplished throughout the transit phase of the mission from DSIF acquisition to lunar touchdown:

		Priorities	
		Pre-Midcourse	Post-Midcourse
3.1	Demonstrate DSIF achievement and maintenance of two-way communications via the command and phase-locked telemetry links during periods of DSIF visibility, as well as performance of precision tracking functions.	1	2
3.2	Demonstrate DSIF capability to receive, record, and process telemetry data for input to the CDC and for post-flight analysis.	1	2
3.3	Demonstrate CDC telemetry subsystem capability to process data for input to OSDP.	1	2
3.4	Demonstrate OSDP capability to edit and format data for transmission to SFOF.	1	2
3.5	Demonstrate capability of DSN ground communication system to provide data transmission between DSIF and SFOF.	1	2
3.6	Demonstrate capability of SFOF to satisfy the defined data processing requirements for real time data analysis and control of the spacecraft.	1	2

Phase 3. (Cont'd)

		Priorities	
		Pre-Midcourse	Post-Midcourse
3.7	Demonstrate capability of CDC/DSIF to generate and transmit commands to the spacecraft.	1	2
3.8	Validate procedures for data reception, processing, transmission, and display for real time analysis for control of the spacecraft.	2	2
3.9	Validate effectiveness of spacecraft performance analysis computer programs as aids to space operations.	2	2
3.10	Evaluate the effective telecommunications decibel margins with respect to predicted values.	2	2
3.11	Demonstrate operation of the spacecraft transmitter in both high and low power modes.	1	2
3.12	Demonstrate that operation of the telecommunication subsystem to accomplish signal processing, data transmission, and command reception is within permissible error rates.	1	2
3.13	Evaluate the telecommunication subsystem performance to compare with design predictions.	2	3
3.14	Demonstrate capability of switching telemetry modes and bit rates by radio command.	2	2
3.15	Evaluate performance of the electrical power system.	2	2
3.16	Evaluate performance of the thermal control system.	2	3

Phase 4. Attitude Reference Acquisition

		Priorities	
		Initial	Post-Midcourse
4.1	Demonstrate the flight control system capability to perform acquisition and lock on the star Canopus.	1	1
4.2	Demonstrate the capability of the flight control system to maintain precision alignment to Canopus.	1	2
4.3	Demonstrate star-mapping capability of the spacecraft.	2	3
4.4	Determine attitude control gas and electrical power usage.	2	3

Phase 5. Coast

		Pre-Midcourse	Post-Midcourse
5.1	Demonstrate proper operation of the spacecraft electrical power, telecommunications, and flight control systems in their normal coast modes.	1	2
5.2	Evaluate the performance of the flight control system in maintaining the required attitude.	2	2
5.3	Evaluate precision tracking data for determining the orbit to the accuracy required for computation of subsequent maneuver commands.	1	2
5.4	Demonstrate automatic switching to inertial hold mode if star lock-on signal is lost.	1	2

Phase 6. Midcourse Maneuver		Priority
6.1	Demonstrate capability and validate procedures for pre-midcourse maneuver orbit determination, landing site selection and subsequent determination of required midcourse maneuver commands.	1
6.2	Validate capability for generation and transmission of required commands to DSIF.	1
6.3	Demonstrate Flight Control System Performance in aligning the thrust axis of the spacecraft in the required direction for the midcourse maneuver.	1
6.4	Demonstrate Flight Control System programmer capability to control midcourse velocity increment.	1
6.5	Demonstrate the capability of the spacecraft electrical power system to support peak loads.	1
6.6	Evaluate spacecraft velocity and acceleration during midcourse thrust phase from telemetry and tracking data.	2
6.7	Evaluate telemetry data on power consumption and the quantity of propellants and attitude control gas expended during midcourse maneuver.	3
6.8	Evaluate telemetry data on vernier engine thrust levels and base heating.	3
6.9	Evaluate adequacy of midcourse velocity correction, if required, to achieve desired orbit.	1
Phase 7. Terminal Maneuver, Retro and Vernier Descent		
7.1	Demonstrate system capability and validate procedures for determination of the required command sequences for the terminal maneuver and descent phase.	2
7.2	Validate procedures for generation and transmission of the required commands to the DSIF.	2
7.3	Demonstrate capability of DSIF/CDC to transmit correct command sequences to the spacecraft at the required times.	2
7.4	Demonstrate capability of A/SPP to deploy planar array to its landing position.	3

Phase 7. (Cont' d)

		Priority
7.5	Demonstrate Flight Control System capability to perform commanded maneuvers to align and maintain the spacecraft thrust axis with the spacecraft velocity vector.	2
7.6	Demonstrate initiation of retro staging sequence at required slant range by Altitude Marking Radar.	2
7.7	Demonstrate Flight Control sequencing of RADVS turn-on, vernier ignition, main retro ignition, retro separation, and attitude control modes.	2
7.8	Demonstrate capability of Flight Control System to utilize vernier thrust to maintain inertially stable attitude during main retro phase.	2
7.9	Demonstrate structural integrity of spacecraft during the thrusting portion of the descent phase.	2
7.10	Demonstrate DSIF capability to maintain receiver lock with spacecraft carrier signal during entire descent phase.	2
7.11	Demonstrate capability of the retro rocket to provide the required spacecraft deceleration.	2
7.12	Demonstrate RADVS generation of the "Reliable Operate" and range-marking signals, as well as conversion of doppler-shift signals to range and velocity components.	2
7.13	Demonstrate Flight Control System execution of the programmed thrust sequence in response to RADVS control signals during vernier descent.	3
7.14	Demonstrate Flight Control System capability to terminate vernier thrust within the required tolerances for transverse and angular velocity and position.	2
7.15	Evaluate telemetry data on radar reflectivity of lunar surface.	3
7.16	Evaluate in-flight tracking data to determine spacecraft landing location.	3
7.17	Evaluate spacecraft orientation at vernier cutoff from telemetry and tracking data.	3
7.18	Evaluate performance of the Flight Control radar, propulsion, and attitude control subsystems.	2

			Priority
Phase 7.	(Cont'd)		
	7.19	Evaluate performance of the telecommunications, power, and thermal control systems.	3
Phase 8.	Lunar Touchdown		
	8.1	Demonstrate "soft" landing on the Moon with spacecraft in upright position.	2
	8.2	Demonstrate capability of spacecraft to land within a preselected region.	2
	8.3	Evaluate telemetry data on impact shock levels.	2
	8.4	Determine spacecraft transverse and angular rates at touchdown.	2
	8.5	Evaluate telemetry data on extension of spacecraft legs after touchdown to verify structural integrity and to determine vertical tilt.	2
	8.6	Demonstrate commanded spacecraft power shutdown after touchdown.	3
	8.7	Evaluate telemetry data for post-landing engineering assessment of all subsystems.	2
	8.8	Demonstrate capability to orient solar panel and planar array for lunar operations.	3
Phase 9.	Lunar Operations		
	9.1	Demonstrate TV performance of obtaining survey pictures of lunar surface and views of spacecraft structures.	3
	9.2	Evaluate telecommunications performance after landing.	3
	9.3	Evaluate electrical power system performance after landing.	3
	9.4	Evaluate thermal control system performance.	3
	9.5	Demonstrate proper mechanism actuation.	3
	9.6	Evaluate TV system performance.	3
	9.7	Evaluate environmental telemetry data obtained during the lunar day.	3
	9.8	Evaluate environmental telemetry data obtained during the lunar night.	3
	9.9	Determine optimum electrical power and thermal management schedule.	3

Phase 9. (Cont'd)

		Priority
9.10	Validate operational techniques and procedures for spacecraft acquisition of Sun and Earth.	3
9.11	Validate procedures for determining TV surveys, generation of required commands, and subsequent transmission to the landing site.	3
9.12	Determine ground system capability to receive and process video inputs in real time, and to provide visual displays and photographic records for use in conducting the TV experiment.	3
9.13	Evaluate post landing tracking data to determine spacecraft lunar location.	3

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	J. C. Nettles (2)
	S. F. Tingley (3)
	C. B. Wentworth (1)
LeRC (GD/C)	Col. J. Heatherly (1)
	R. Hunt (1)
	M. Kaplan (2)
	G. Musicant (1)
	R. Rovenger (2)
STL	A. H. Zimmerman (3)
GD/C	P. D. Adams (1)
	J. J. Andrews (2)
	F. B. Anthony (4)
	M. R. Barlow (2)
	R. Benzwi (1)
	H. C. Cherin (1)
	R. V. Day (1)
	D. Flowers (4)
	B. R. Foushee (1)
	H. Gatshoff (1)
	G. L. Hansen (1)
	W. Hicks (1)
	K. Kachigan (1)
	F. E. Nickerson (1)
	R. S. Wentink (1)
	R. P. White (3)

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	R. K. Cheng (1)
	T. D. Collison (1)
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	R. R. Gunter (1)
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	E. N. King (1)
	L. G. Ludwig (2)
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	C. M. Meredith (2)
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NASA Headquarters	<u>OSSA</u> B. Milwitzky (3) O. Nicks (1) W. Jakobowski (1) F. Zihlman (1) <u>OTDA</u> F. B. Bryant (4) C. P. Wilson (1)

APPENDIX A

Abbreviations

AFETR:	Air Force Eastern Test Range
A/SPP:	Antenna and Solar Panel Positioner
CDC:	Command and Data Handling Console
DSIF:	Deep Space Instrumentation Facility
DSN:	Deep Space Network
OSDP:	On-Site Data Processing System
PRD:	Program Requirements Document
RADVS:	Radar Altimeter and Doppler Velocity Sensor
SFOF:	Space Flight Operations Facility

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